Blackout: A Case Study of the 2003 North American Power Outage with Exercises

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Blackout: A Case Study of the 2003 North American Power Outage

Key Questions

- What were the main vulnerabilities and threats related to the Electricity Subsector of the Energy Sector at the time of the blackout?
- What will be key challenges for the resilience of the Electricity Subsector in the future?
- What strategies could mitigate these challenges and increase resilience in the future?

Case Narrative

Introduction: "There are a lot of different theories..."

In many ways 14 August 2003 was a typical summer day in the eastern part of the United States and Canada. It was relatively hot—the mercury rose above 90 degrees Fahrenheit in some areas—but it was not excessively hot, and there were no strong weather systems. It began as a slow news day, reflecting a more relaxed pace of business as many Americans and Canadians took time off from work to enjoy the end of the summer. In Washington, D.C. Congress was in recess, and President Bush traveled to California to meet with wounded soldiers and to attend campaign events.

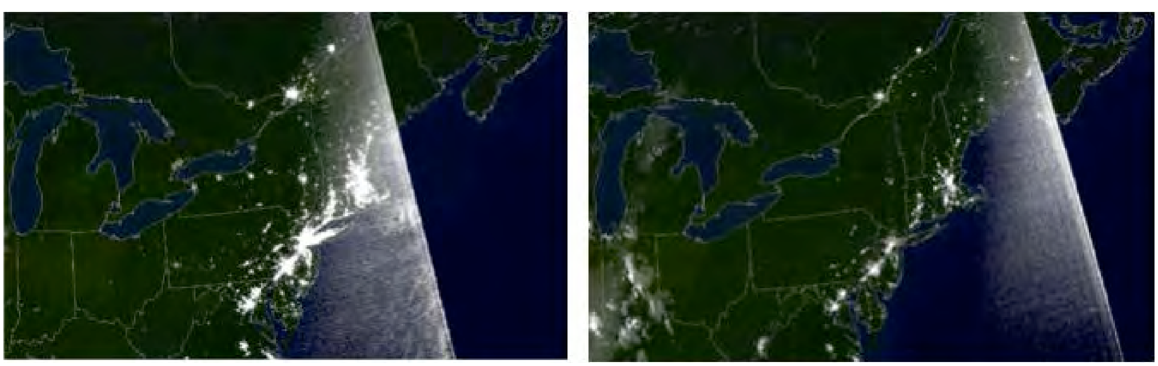
But this lazy summer day was unfolding at an unusual time in U.S. history. The second anniversary of the 9/11 terrorist attacks was quickly approaching, the Department of Homeland Security was less than a year old, and the war in Iraq had begun only five months earlier. The ink was barely dry on Homeland Security Presidential Directive (HSPD) 5, which made the Secretary of Homeland Security the principal Federal official for domestic incident management. Despite the casual outward appearance of things, on 14 August 2003, the Nation was inwardly in turmoil, focused on securing the Homeland against new threats that seemed to emerge on a daily basis. Just the day before, the U.S. Department of State issued a travel warning alerting citizens to "credible information that terrorists have targeted Western aviation."[1] Earlier in the week, the "Blaster" worm had infected hundreds of thousands of computers—an attack that came on the heels of the "Slammer" cyber attack in January that had crashed computers at FirstEnergy's Davis-Besse nuclear power plant outside Toledo, Ohio.[2] The Nation was at war at home and abroad.

And then, a little after 4 p.m. Eastern Standard Time (EST), the lights went out over a large swath of the Northeast United States and Canada. In a matter of seconds, large portions of Ohio, Michigan, Pennsylvania, Massachusetts, New York, Connecticut, New Jersey, and Ontario, Canada went dark. The loss of electricity not only caused the lights

to go out, but also shut down airports, subways, trains, and tunnels. The loss of electric power suspended the operation of automatic doors, elevators, and entire drinking water utilities. It forced hospitals to run on limited power produced by back-up generators.[3] Cell phone towers, cash registers, and ATMs went out of commission. In New York City, evening commuters stranded in a blackened city were forced to walk home because the city's public transportation system had ground to a halt, evoking memories of the 11 September 2001 terrorist attacks.[4] Local officials in New York City predicted that even once power was restored, it would take upwards of six additional hours before public transportation resumed operations. Elsewhere, the effects were also keenly felt. In Cleveland, Ohio, where electric pumps at the water utility shut down and deprived 1.5 million customers of drinking water, the mayor denounced price gouging by stores selling essentials such as water and batteries.[5]

As President Bush ate lunch with soldiers in California, one of his senior aides informed him that a massive blackout had hit the East Coast. With the specter of terrorism looming and millions of Americans out of power on a warm summer day, the President's suite at the Hyatt transformed into the West Coast White House Situation Room. From there, the President—with the help of Department of Homeland Security Secretary Tom Ridge, White House aides and multiple U.S. Government agencies in Washington, including the Department of Homeland Security, Federal Bureau of Investigation, Central Intelligence Agency, and Department of Energy—set about the task of responding to the most massive blackout in U.S. history. As electricity officials worked to restore power and began to sort through the information to determine the cause, White House Communications Director Dan Bartlett summed up the situation: "There are a lot of different theories and we wanted [sic] to make sure that we get to the bottom of it."[6] As officials struggled to grapple with the crisis, one thing was immediately clear: the Energy Sector had suffered a huge blow with consequences that affected millions of Americans.

Photo 1: Satellite Images of the Night Before (left) and Night After (right) the 14 August 2003 Blackout



Source: National Oceanic and Atmospheric Administration News, United States Department of Commerce, http://www.noaanews.noaa.gov/stories/images/nightlights-081403-0121z2.jpg.

The Energy Sector: Fueling the Nation

The U.S. Energy Sector includes a diverse conglomeration of energy resources and assets spanning all 50 States, as well as U.S. Territories. A large number of owners and

operator entities, including privately-held and some publicly held Federal, State, and Local entities, comprise the sector. The vastness of the sector and the vital role it plays in everyday life make it both critical and challenging to protect.

The Energy Sector is comprised of three subsectors: electricity, petroleum, and natural gas. (See Figure 1) Together, these Subsectors produced an astounding 70 quadrillion British thermal units (Btu) in 2003. Even so, the United States had been a net energy importer for the prior fifty years.[7] Total United States energy consumption in 2003, for example, topped 97 quadrillion Btu, resulting in a net import of 27 quadrillion Btu. This level of energy consumption was nearly one-fourth of total world energy consumption at that time.[8]

Figure 1: Energy Subsectors and Supporting Assets and Resources

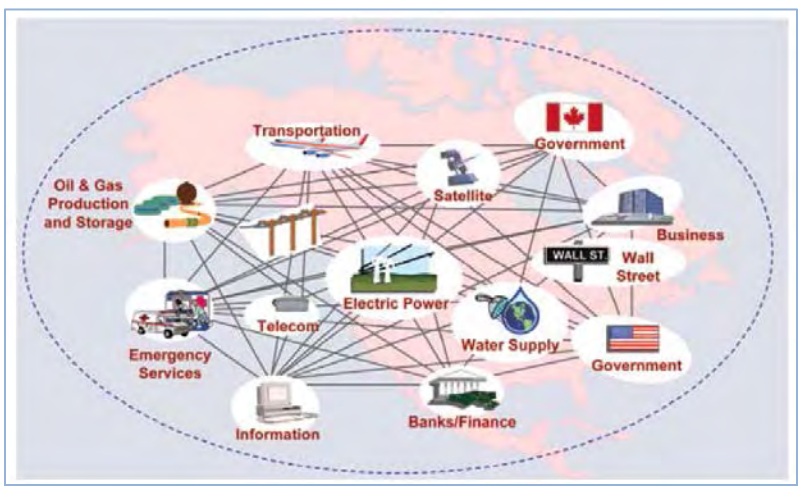
Electricity	Petroleum	Natural Gas
• Generation	• Crude Oil	• Production
– Fossil Fuel Power Plants	– Onshore Fields	– Onshore Fields
▪ Coal	– Offshore Fields	– Offshore Fields
▪ Natural Gas	– Terminals	• Processing
▪ Oil	– Transport (pipelines)[a]	• Transport (pipelines)[a]
– Nuclear Power Plants[a]	– Storage	• Distribution (pipelines)[a]
– Hydroelectric Dams[a]	• Petroleum Processing Facilities	• Storage[b]
– Renewable Energy	– Refineries	• Liquefied Natural Gas Facilities[b]
• Transmission	– Terminals	• Control Systems
– Substations	– Transport (pipelines)[a]	• Gas Markets
– Lines	– Storage	
– Control Centers	– Control Systems	
• Distribution	– Petroleum Markets	
– Substations		
– Lines		
– Control Centers		
• Control Systems		
• Electricity Markets		

[a] Hydroelectric dams, nuclear facilities, rail, and pipeline transportation are covered in other SSPs.
[b] Certain infrastructure of this asset type are regulated by the Chemical Facility Anti-Terrorism Standards (CFATS). The final tiering of the facilities covered by the CFATS was not completed at the time of this report.

Source: Energy Sector-Specific Plan. An Annex to the National Infrastructure Protection Plan. United States Departments of Homeland Security and Energy. 2010. http://energy.gov/sites /prod/files/oeprod/DocumentsandMedia/Energy_SSP_2010.pdf, page 9.

The Energy Sector provides fuel to all of the 15 other critical infrastructure sectors, making them dependent on the Energy Sector to function. In fact, according to the Department of Homeland security, "more than 80 percent of the country's energy infrastructure is owned by the private sector, supplying fuels to the transportation industry, electricity to households and businesses, and other sources of energy that are integral to growth and production across the nation."[9] Likewise, the Energy Sector is also dependent on many of these sectors. The result is a web of critical interdependencies. (See Figure 2) Many sector interdependencies, such as those within the Transportation Sector's pipelines, are longstanding interdependencies, while others, such as those within the Information Technology Sector, have become more pronounced only over the past

Figure 2: Web of Energy Segment Interdependencies



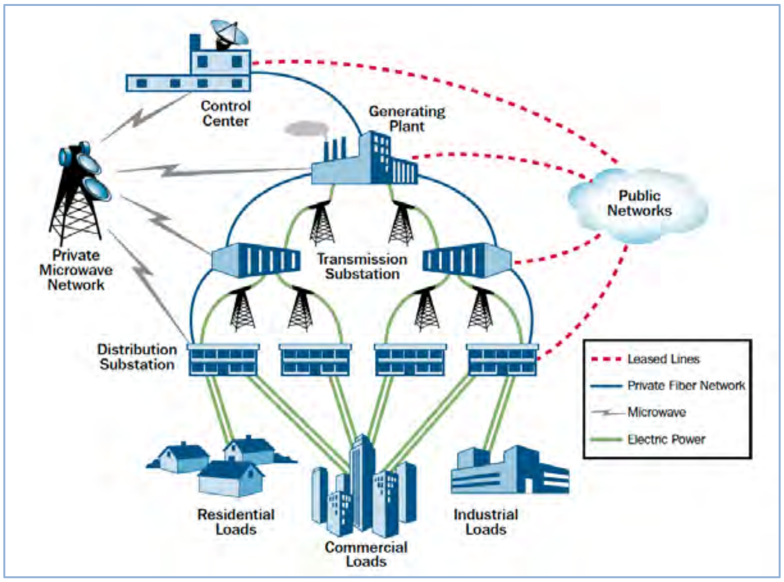
Source: Energy Sector-Specific Plan. An Annex to the National Infrastructure Protection Plan. United States Departments of Homeland Security and Energy. 2010. http://energy.gov/sites /prod/files/oeprod/DocumentsandMedia/Energy_SSP_2010.pdf, page 18.

few decades as the sector has incorporated new technologies into its systems. Whether new or old, the complexity of this web of interdependencies means that a disruption in one area, such as electricity, will affect many other areas.

Electricity: A High Wire Balancing Act

Electricity is a vital commodity whose unique characteristics require a delicate and constant balance of supply and demand. Unlike other commodities, electricity must be consumed almost immediately upon generation, and it cannot easily be stored. It is generated using various fuel sources, then transmitted long distances at very high voltages, and subsequently distributed at lower voltages to customers. (See Figure 3)

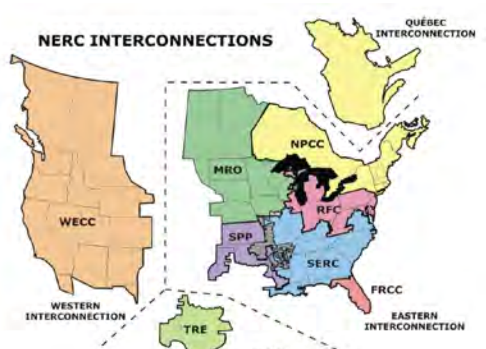
Figure 3: Electricity Generation and Supply



Source: Energy Sector-Specific Plan. An Annex to the National Infrastructure Protection Plan. United States Departments of Homeland Security and Energy. 2010. http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/Energy_SSP_2010.pdf, page 10.

From the late 1800s through the mid-1930s, "the grid" was merely a patchwork of independently owned and operated utilities. These utilities provided generation, transmission, and distribution, and they typically operated vertically integrated as monopolies within their service territory. As generation and transmission capacity grew over the subsequent decades and more non-utilities became energy producers, the grid grew to incorporate many more energy assets and resources. During these early years, electricity was generated primarily by burning coal. But by the late 1970s new technologies such as nuclear power had taken hold and new technologies and laws ensured that alternative sources of energy, such as hydroelectric power, and renewable energy sources, such as wind and solar energy, would also be used to support the Nation's growing energy needs.

Figure 4: Four North American Interconnections

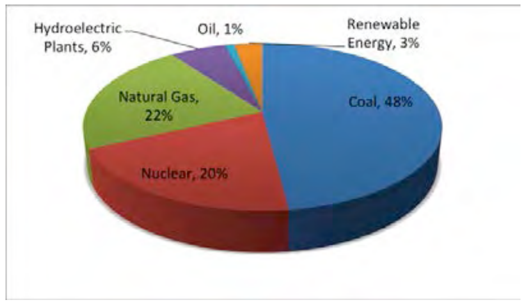


Source: Energy Sector-Specific Plan. An Annex to the National Infrastructure Protection Plan. United States Departments of Homeland Security and Energy. 2010. http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/Energy_SSP_2010.pdf, page 26.

In 2003, at the time of the blackout, the North American electricity grid had grown to include four distinct grids, called interconnections. (See Figure 4) Generation had expanded to include a range of energy types, although coal remained the single largest source. (See Table 1) To perform the main functions of generation, transmission, and distribution, the electricity

subsector had by this time become “an integrated system of generating plants, high voltage transmission lines, local distribution facilities, [and] industrial control systems...”[10] This diverse set of players had to “operate as a contemporaneous network in real time or in a synchronous manner to provide stable and reliable electricity to consumers.”[11] And all participated in securing and improving the resilience—the ability to withstand natural disasters, manmade accidents, or attacks— of the U.S. Energy Sector. This included more than 6,000 power plants with over 1,000 gigawatts of installed generation produced by coal, nuclear power plants, natural gas, hydroelectric dams, oil, and renewable sources.[12]

Table 1: Electric Power Generation by Type, 2003



Source: Based on data from www.eia.gov

Whether electricity is generated using fossil fuels (coal, petroleum, and natural gas), renewable energy (wind, solar, geothermal, solar thermal, and hydro-electric), or nuclear energy, several key physical, cyber, and human elements play a role in ensuring a functioning grid. Because electricity is consumed almost instantaneously after it is generated, operators use industrial control systems (ICS) such as supervisory control and data acquisition (SCADA) systems to predict, monitor and balance supply and demand. Changes in any of the monitored activities are detected by the system, which brings the change to the attention of the operators.[13] These SCADA systems are essential for early detection and mitigation of a host of potential problems that can arise on any given day that affect supply and demand. New “smart” technologies such as sensors for monitoring loads, communication networks to ensure timely, real-time monitoring and information sharing, and automated control devices to manage the system had begun to emerge that allow for better real-time monitoring and control, but as of 2003 these technologies were still not in use in key areas.[14]

To better coordinate this delicate balancing act, many states and regions by 2003 used not-for-profit independent system operators (ISO) or regional transmission operators (RTO) to help manage the transmission of electricity in different areas via industrial control systems. ISOs are single-state or relatively small multiple state entities established by federal order. RTOs perform similar or expanded services across a multi-state area and have been approved by the federal government. Working with utility company power engineers, the ISOs and RTOs help to monitor and balance loads and ensure that they are operating within voluntary limits. They in turn coordinate with the North American Electric Reliability Corporation (NERC), whose mission as an international, independent, self-regulatory, not-for-profit organization is to ensure the reliability of the bulk power system (generation and high-voltage transmission). NERC was founded in 1968 by the electric utility industry to develop and promote mandatory rules and voluntary standards for the reliable operation of the North American transmission systems. The U.S. Federal Energy Regulatory Commission (FERC), a U.S. government organization, in turn oversees NERC.

This diverse conglomeration of resources, assets, and players together ensure that electric power reliably reaches millions of North American residential, commercial, and industrial customers every minute of every day. The immense challenges of ensuring reliability and resilience of the electric subsector became rapidly apparent on 14 August 2003.

From Minor to Massive: "We Got Big Problems, Buddy"

The incident began as a series of relatively minor glitches early on the afternoon of 14 August 2003. As a few plants and transmission lines failed, the two relevant ISOs—Midwest Independent System Operator (MISO) and PJM Interconnection (PJM)—and the electric power utilities whose areas those ISOs oversee—particularly First Energy (FE) and American Electric Power (AEP)—worked to understand what was happening. The ISOs fielded calls from across the region throughout the afternoon as transmission lines tripped and power plants automatically shut down. The tipping point came just after four o'clock when a series of accumulated failures among the physical "grid" itself, the computers monitoring it, and the human operators resulted in a perfect storm that resulted in a massive cascade of failures. (See Figure 5)

> Chronology of the Blackout[15]
>
> 2 p.m. FirstEnergy Corp.'s Eastlake Unit 5, a 680-megawatt coal generation plant in Eastlake, Ohio, trips off.
>
> 3:06 p.m. FirstEnergy's Chamberlain-Harding power transmission line, a 345-kilovolt power line in northeastern Ohio, trips. The outage put extra strain on FirstEnergy's Hanna-Juniper line, the next to go dark.
>
> 3:32 p.m. Extra power coursing through FirstEnergy's Hanna-Juniper 345-kilovolt line heats the wires, causing them to sag into a tree and trip.
>
> 3:41 p.m. An overload on First Energy's Star-South Canton 345-kilovolt line trips a breaker at the Star switching station, where FirstEnergy's grid interconnects with a neighboring grid owned by the American Electric Power Co. AEP's Star station is also in northeastern Ohio.
>
> 3:46 p.m. AEP's 345-kilovolt Tidd-Canton Control transmission line trips where it interconnects with FirstEnergy's grid, at AEP's connection station in Canton, Ohio.
>
> 4:06 p.m. FirstEnergy's Sammis-Star 345-kilovolt line, also in northeast Ohio, trips, then reconnects.
>
> 4:08 p.m. Utilities in Ontario and the eastern United States see wild power swings.
>
> 4:09 p.m. The already lowered voltage coursing to customers of Cleveland Public Power, inside the city of Cleveland, plummets to zero. "It was like taking a light switch and turning it off," said Jim Majer, commissioner of Cleveland Public Power. "It was like a heart attack. It went straight down from 300 megawatts to zero."
>
> 4:10 p.m. The Campbell No. 3 coal-fired power plant near Grand Haven, Mich., trips off.
>
> 4:10 p.m. A 345-kilovolt line known as Hampton-Thetford, in Michigan's thumb region, trips.
>
> 4:10 p.m. A 345-kilovolt line known as Oneida-Majestic, in southeast Michigan, trips. According to post blackout reports, as a result of these trips, the entire northeastern United States and Canada became an electrical island separated from the rest of the Eastern Connection.
>
> 4:11 p.m. Orion Avon Lake Unit 9, a coal-fired power plant in Avon Lake, Ohio, trips.
>
> 4:11 p.m. A transmission line running along the Lake Erie shore to the Davis-Besse nuclear plant

near Toledo, Ohio, trips.

4:11 p.m. A transmission line in northwestern Ohio connecting Midway, Lemoyne and Foster substations trips.

4:11 p.m. The Perry Unit 1 nuclear reactor in Perry, Ohio, shuts down automatically after losing power.

4:11 p.m. The FitzPatrick nuclear reactor in Oswego, N.Y., shuts down automatically after losing power.

4:12 p.m. The Bruce Nuclear station in Ontario shuts down automatically after losing power.

4:12 p.m. Rochester Gas and Electric's Ginna nuclear plant near Rochester, N.Y., shuts down automatically after losing power.

4:12 p.m. Nine Mile Point nuclear reactor near Oswego, N.Y., shuts down automatically after losing power. New York City plunges into darkness.

4:15 p.m. FirstEnergy's Sammis-Star 345-kilovolt line, in northeast Ohio, trips and reconnects a second time.

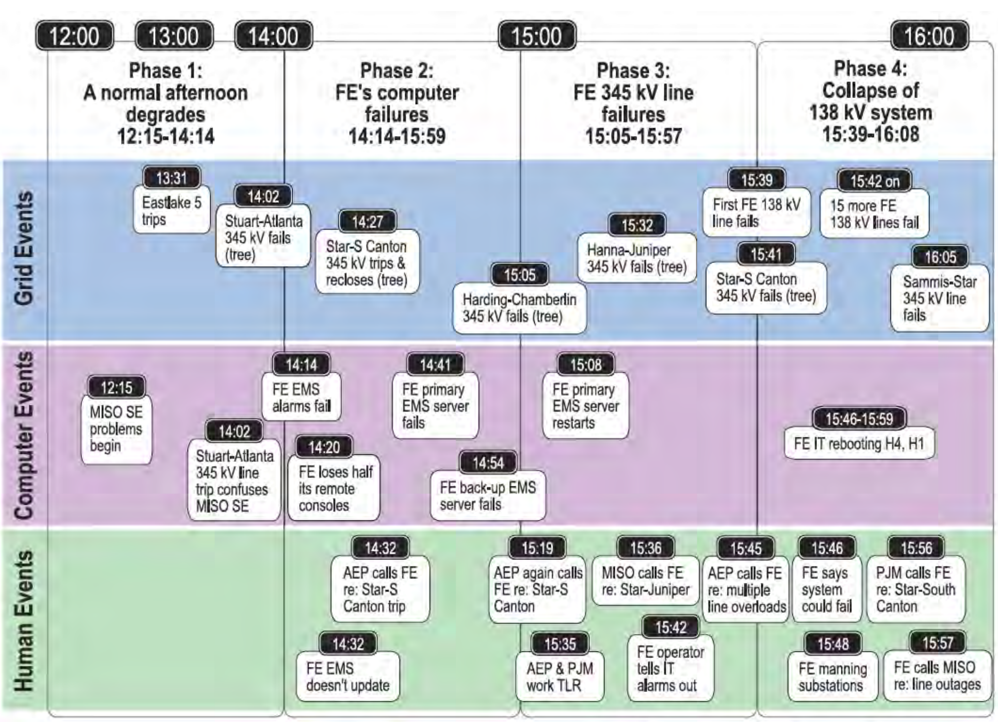
4:16 p.m. Oyster Creek nuclear plant in Forked River, N.J., shuts down automatically because of power fluctuations on the grid.

4:17 p.m. The Enrico Fermi Nuclear plant near Detroit shuts down automatically after losing power.

4:17 to 4:21 p.m. Power transmission lines in Michigan trip.

4:25 p.m. Indian Point nuclear power plants 2 and 3 in Buchanan, N.Y., shut down automatically after losing power.

Figure 5: Timeline of Events, 14 August 2003



Source: "Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations." U.S.-Canada Power System Outage Task Force. April 2004. https://reports.energy.gov/BlackoutFinal-Web.pdf. page 46.

By 4:25, the outage had swept through eight states and Canada, covering 9,600 square miles—an area that supplies electricity to 50 million people.[16] MISO operator Don Hunter and off-duty MISO operator Jay Egan struggled to understand exactly what had happened.[17]

Don Hunter: MISO Carmel, this is Don.
Jay Egan: Don?
Don Hunter: Yes.
Jay Egan: Yes, this is Jay.
Don Hunter: Hey, Jay.
Jay Egan: What's happening?
Don Hunter: Oh, all hell's breaking loose, good buddy.
Jay Egan: I heard the east coast is like dark?
Don Hunter: Yes, I don't know to the extent of it. There's so many people in here, I can't take it. Apparently, it's centered around the Lake there, Lake Erie, and DTE, First Energy. I know we had problems –- we had multiple problems, starting out, but –- and just freak coincidences happening, you know? And then suddenly a couple low voltages, but I'm not sure if it was our area, or not, that triggered the full event, so…
Jay Egan: Well, all right, well I'll let you go, you're probably busy and I just thought I'd call. My mother called me from Minnesota. I don't know, I'm off.
Don Hunter: Hey, I've got to get this phone, man.
Jay Egan: Bye.
Don Hunter: Okay, bye.

MISO worked the problem through the afternoon into the evening, fielding calls from across the region in an effort to share information and determine the full extent of the blackout.[18]

Detroit-Edison Jeff Sharrow: Do we have a cause or any major event that happened?
Don Hunter: At this time, we do not, so we're kind of on hold, and everybody is protecting their systems right now.
Sharrow: Okay.
Hunter: Everybody is protecting your ACE.
Sharrow: Okay. So New York is flat, that area.
Hunter: Yeah. That's what I'm hearing, New York City.
Sharrow: And Albany.
Hunter: We're catching things on the news too, so in Albany, New York. And we heard that you guys have, you know, lost your grid. We know that Virginia Power is doing some swinging down there also trying to control things, so we're kind of taking it as it comes right now. We don't have a lot of information right now.
Sharrow: So it's a major disservice on the east side.
Hunter: It seems to be.
Sharrow: Okay.
Hunter: Okay.

Sharrow: Thank you, sir.
Hunter: All righty.
Sharrow: Bye.
Hunter: Bye.

When the Lights Went Out: Blackouts in History

American households lose power for more than three hours per year on average, but massive blackouts on the order of August 2003 in which millions of customers lose power simultaneously remain rare events.[19] Historically, the causes of large-scale outages have been traced to both technological failures and natural causes. In the wake of past large-scale outages, industry had increased self-regulation of reliability standards, but in 2003, the regulations remained voluntary and were unevenly adopted across the Nation.

The November 9, 1965 blackout that sent thirty million people into darkness throughout the Northeast United States and Canada was traced to a single faulty relay at the Sir Adam Beck Station Number 2 in Ontario, Canada. The failure caused a transmission line to open, or disconnect. This, in turn, caused a cascade of line overloads that ultimately caused power generation plants throughout the region to shut down automatically.[20] The blackout prompted electric utility providers in 1968 to create an electricity reliability council—now known as the North American Electric Reliability Corporation—to develop voluntary standards for important aspects of industry operations such as equipment testing, reserve generation capacity, and reliability.

In addition to technological failures, natural events have also contributed to large-scale blackouts. The above-ground disposition of the physical aspects of the grid, particularly transformers and transmission lines, make it vulnerable to the elements and to the effects of extreme natural events. On 13-14 July 1977, New York City was once again plunged into darkness, but this time as a result of a series of four lightening strikes on transmission lines north of the city. The blackout sparked violence, looting, and arson throughout many parts of the city, and police made over 3,700 arrests across the city.[21] Outrage over the blackout and the ensuing melee prompted the "first limited reliability provision in federal legislation" that enabled the U.S. government to propose voluntary standards. The government never exercised this authority.[22]

In July and August of 1996, extreme heat sparked two major blackouts that extended across the Western United States and Canada. Triple digit temperatures caused lines to sag into inadequately trimmed trees, causing the widespread power failures. The outages prompted some members of the Western Systems Coordinating Council to agree to pay fines if they violated specific reliability standards.[23] Otherwise, standards remained voluntary throughout the industry and violations generated no penalties.

While these types of extreme weather events have been rare in the past, statistics suggest that they may be growing in frequency. Some weather experts, including the world's largest reinsurer, Munich Re, warn that North America will experience an increase in the frequency and intensity of extreme weather events in the future.[24] This likelihood of

extreme volatility causes a level of uncertainty that experts urge can only be mitigated by building a more resilient Sector that embraces flexible responses; increased connectivity, communication, and collaboration across organizational boundaries; a willingness to challenge assumptions; and, preparing for a range of possible outcomes that stress continuity, response, and recovery.[25]

Consequences of the 2003 Blackout: "It's a serious situation"

With a large swath of the Northeast United States and Canada without power in August of 2003, industry and government officials scrambled to restore service to the affected areas and identify the cause. Four and a half hours after the blackout began, the White House updated the Nation on what was known about the causes and consequences of the blackout. Calling the blackout a "serious situation," President Bush reassured the public that the cause was not related to terrorism.[26] With the specter of terrorism ruled out, the Nation turned its attention to the consequences of the blackout that was being experienced by millions of Americans.

Figure 6: Outage Area in the United States

Source: U.S. Department of Transportation, http://www.fhwa.dot.gov/publications/publicroads/04sep/04.cfm.

Nowhere was the impact of the blackout felt more deeply than New York City, where the human and economic tolls were large and immediate. It took only thirty hours to restore power to the entire city.[27] During that time transportation had ground to a halt, leaving most of the city in the heat without a way home. With traffic lights out, the streets became clogged; subway trains stopped; and the three major metropolitan area airports cancelled flights. Businesses closed because computers and cash registers would not operate. Cell phones became useless because cell towers stopped operating. The overall economic impact of the blackout was estimated to be between $4-6 billion dollars for the affected regions.[28] New York's share was over $1 billion—or $36 million an hour—according to the New York City comptroller. Over $800 million of this was attributed to loss of productivity by closed businesses, while another $250 million was lost in perishable goods. Maintaining security was expensive, but the city avoided the widespread looting associated with the 1977 blackout. The mayor estimated that overtime for police and other city workers totaled $10 million.[29] City officials attributed the relative calm to post-9/11 security procedures that allowed precincts to operate independently and augment police manpower by upwards of 40 percent. The plan seemed to work; of the 850 arrests made overnight, police attributed only 250 of them directly to the blackout.[30]

Even before the lights came back on, speculation raged about the root cause of the blackout. Much of the commentary focused on aging infrastructure and the impact that

such a widespread outage was having on public confidence. As former Department of Energy Secretary Bill Richardson put it, “we’re a superpower with a third world electricity grid.”[31] Within a day of the blackout the House Energy and Commerce Committee announced an investigation into the causes of the failure, and the White House announced that a U.S. – Canada taskforce would work to “identify the causes of the recent power outage” and “seek solutions to help prevent future outages.”[32]

Six months later, the U.S.-Canada Power System Outage Task Force found that a combination of human error and equipment failures had caused the blackout, specifically:

> “a failure of the alarm processor in the control system of FirstEnergy, an Ohio-based electric utility, prevented control room operators from having adequate situational awareness of critical operational changes to the electrical grid. When several key transmission lines in northern Ohio tripped due to contact [sic] with trees, they initiated a cascading failure of 508 generating units at 265 power plants across eight states and Canada.”[33]

In addition to inadequate vegetation management, the Taskforce also found problems with human, cyber, and physical aspects of the grid, including: a failure to ensure operation within secure limits; failure to identify emergency conditions and communicate that status to neighboring systems; inadequate operator training; inadequate regional-scale visibility over the power system; inadequate coordination of relays and other protective devices or systems; inadequate interregional visibility over the system; dysfunction of a control area’s SCADA system; and inadequate backup capability of that system.[34] In all, the Task Force made a set of 46 sweeping recommendations. With a clear understanding of what had caused the blackout, government and industry officials turned their attention to developing strategies that could help to avert such large-scale blackouts in the future. Their task was great.

Recommended Reading

“Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations.” U.S.-Canada Power System Outage Task Force. April 2004. https://reports.energy.gov/BlackoutFinal-Web.pdf.

“Energy Sector-Specific Plan. An Annex to the National Infrastructure Protection Plan.” United States Departments of Homeland Security and Energy. 2010. http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/Energy_SSP_2010.pdf

Blackout: Critical Infrastructure Security and Resilience in Exercises

The 2003 North American Blackout was a widespread incident that serves as a robust case study of the Energy Sector, illustrating the challenges presented by the unique characteristics of the Electricity Subsector and the implications of interdependencies for critical infrastructure security and resilience (CISR). Given the importance of planning activities for CISR professionals, the following exercises center on strategy and planning activities in an environment that has many interdependencies. The exercises also model robust critical thinking and small group processes to provide a roadmap for tackling the types of challenges faced by CISR professionals.[35]

The goal of the exercises is to employ sound critical thinking about strategy and planning activities, not simply to model the known outcome.[1] To this end, the exercises help the learner employ a robust and structured approach to these activities and explicitly identify the value added by using them. Many times the value of a technique lies in the conversation that it prompts about evidence, factors, assumptions, and gaps that would otherwise be overlooked. Learners should judge their performance, therefore, on *how* they have conducted their analyses rather than on the specific case outcome. As a former CEO of a major U.S. company noted, his "company almost never got the crises they prepared and practiced for…but with resilient processes and people, they were able to manage whatever crises came their way."[36]

Exercise 1. Strategic Planning Divergent Thinking Phase: Elements of Future Resilience for the Electricity Subsector.

Brainstorming is a process that follows specific rules and procedures designed to generate new ideas and concepts. The stimulus for creativity comes from two or more people bouncing ideas off each other. A brainstorming session usually exposes participants to a greater range of ideas and perspectives than any one person could generate alone, and this broadening of views typically results in a better product.

Structured Brainstorming is a systematic twelve-step process (described below) for conducting group brainstorming. It is most often used to identify key drivers or all the forces and factors that may come into play in a given situation. If, however, a group is not possible, there is still value in thinking as imaginatively and divergently as possible by adjusting the technique for use by one person. The goal of brainstorming, whether used in a group or by oneself, is to think as exhaustively as possible.

Task: What are the drivers (factors, actors, issues) that affect Electricity Subsector resilience?

Structured Brainstorming Technique Steps

Step 1: Gather a group of CISR learners.

[1] Please see the Instructor Materials for full notional solutions and a case conclusion.

Step 2: Pass out sticky notes and Sharpie-type pens or markers to all participants. Inform the team that there is no talking during the sticky-notes portion of the brainstorming exercise.

Step 3: Present the team with the following question: What are the drivers (factors, actors, issues) that affect Electricity Subsector resilience?

Step 4: Ask the group to write down responses to the question with a few key words that will fit on a sticky note. After a response is written down, the participant gives it to the facilitator who then reads it aloud. Sharpie-type or felt-tip pens are used so that people can easily see what is written on the sticky notes later in the exercise.

Step 5: Place all the sticky notes on a wall randomly as they are called out. Treat all ideas the same. Encourage participants to build on one another's ideas.

Step 6: Usually an initial spurt of ideas is followed by pauses as participants contemplate the question. After five or ten minutes there is often a long pause of a minute or so. This slowing down suggests that the group has "emptied the barrel of the obvious" and is now on the verge of coming up with some fresh insights and ideas. Do not talk during this pause even if the silence is uncomfortable.

Step 7: After two or three long pauses, conclude this divergent-thinking phase of the brainstorming session.

Step 8: Ask all participants (or a small group) to go up to the wall and rearrange the sticky notes by affinity groups (groups that have some common characteristics). Some sticky notes may be moved several times, and some may be copied if the idea applies to more than one affinity group.

Step 9: When all sticky notes have been arranged, ask the group to select a word or phrase that best describes each grouping.

Step10: Look for sticky notes that do not fit neatly into any of the groups. Consider whether such an outlier is helpful or the germ of an idea that deserves further attention.

Step 11: Assess what the group has accomplished. Can you identify four or five key factors or forces that are particularly salient to Electricity Subsector resilience?

Step 12: Present the results, describing the key themes or dimensions of the problem that deserve investigation.

Analytic Value Added

Which drivers have near-term, mid-term, and longer-term consequences for Electricity Subsector resilience? Did our ideas group themselves into coherent affinity groups? Were there any outliers or sticky notes that seemed to belong in a group all by themselves? Did the outliers spark new lines of inquiry? Did the labels we generated for each group accurately capture the essence of that set of sticky notes? What additional information should we track down about the threats and vulnerabilities we generated? Where does that information reside and to whom should we speak about it?

Exercise 2. Strategic Planning Convergent Thinking Phase: Creating a Forward-looking Strategy

There are many factors that could shape the future of the highly interdependent Electricity Subsector. Using a scenarios technique can be a useful way to develop an understanding of the multiple ways in which a situation might evolve. The analytic value added by using scenarios techniques lies not in the specifics of the scenarios themselves but in the analytic discussion about which drivers will affect a particular scenario, the implications of each scenario for planning, and the specific action items that emerge.

Task: Using various combinations of drivers developed in Exercise 1, create a range of future scenarios for the Electricity Subsector over the next ten years.

Futures Technique Steps

Step 1: Clearly define the focal issue and the specific goals of the Simple Scenarios exercise.

Step 2: Using the affinity group drivers developed in Exercise 1, create a matrix with the list of drivers down the left side, as shown in the table below.

Step 3: List four different scenarios—best case, worst case, wildcard, and at least one other, for example, a nightmare scenario—across the top of the matrix.

	Best Case	Worst Case	Nightmare
Affinity Group Driver 1			
Affinity Group Driver 2			
Affinity Group Driver 3			
Affinity Group Driver 4			
Affinity Group Driver 5			

Step 4: Working across the matrix, consider how each driver would affect each scenario. Each scenario is assigned a positive, negative, or neutral value for each driver. The values are strong or positive (+), weak or negative (–), and blank if neutral or no change. ***An easy way to code the matrix is to assume that the scenario already occurred and ask, "Did driver A***

exert a strong, weak, or neutral influence on the outcome?"

Step 5: Look across the matrix to evaluate how each driver discriminates among the scenarios. If a driver has the same value across all scenarios, it is not discriminating and should be deleted or further defined.

Step 6: For each scenario, use the coded matrix to illustrate how the interplay of the drivers would emerge to create the scenario. Write a no longer than one-page story to describe the future scenario and/or how it might come about.

Step 7: For each scenario, describe the implications for the Electricity Subsector. The implications should be focused on variables that the CISR planners and policymakers could influence to shape the outcome.

Analytic Value Added

Which aspects of the scenarios most deserve attention and why? Is there a particular scenario that stands out, and why? What action items emerge? Are these action items feasible given current technologies and financial resources?

Exercise 3. Strategic Planning: Strategic Planning Troubleshooting and Mitigation Strategies

Strengths-Weaknesses-Opportunities-Threats (SWOT) Analysis can be used to evaluate a goal, objective, or future scenario by providing a framework for organizing and collecting data for strategic planning. SWOT is designed to illuminate areas for further exploration and more detailed planning, and therefore it is typically an early step in a robust planning process. SWOT analysis can also be an important part of troubleshooting plans and identifying specific actions that may improve the chances of success.

Task: Choose at least one of the future scenarios generated in Exercise 2 and enumerate the strengths, weaknesses, opportunities, and threats for the scenario.

SWOT Technique Steps

Step 1: Clearly define the future scenario to be analyzed. Use one of the paragraphs generated in Exercise 2 as a point of departure.

Step 2: Enumerate each of the Strengths, Weaknesses, Opportunities, and Threats associated with the future scenario.

Step 3: Use the SWOT table to generate as many strengths, weaknesses, opportunities, and threats as possible. If there are none, use the drivers generated in Exercise 1 to prompt deeper thinking about the scenario. Also, challenge any underlying assumptions about those already developed to generate even more ideas.

Strengths 1. 2. 3.	Weaknesses 1. 2. 3.
Opportunities 1. 2. 3.	Threats 1. 2. 3.

Analytic Value Added:

Using the results of the SWOT analysis, create a similar table and enumerate how one might bolster and use strengths, mitigate and improve upon weaknesses, create and exploit opportunities, and counter threats? Do any ideas emerge that deserve immediate attention or action, and why?

[1] "U.S. Warns of Airport Terrorism in Saudi Arabia," Bloomberg, August 13, 2003, http://www.bloomberg.com/apps/news?pid=newsarchive&sid=areZazlnvDaA&refer=uk.

[2] Brian Krebs, "Hackers Did Not Cause Blackout," Washington Post, November 19, 2003, www.washingtonpost.com.

[3] Backup generator planning generally follows the one thirds rule: 1/3 of all backup generators will fail immediately; 1/3 of the remaining generators will fail within the next 12 hours leaving only 1/3 of all generators operating as "planned." The one thirds rule is used by the Department of Energy (DOE) as part of its Emergency Support Function #12 (DOE+ESF-12) National Response Framework requirement to maintain "continuous and reliable energy supplies for the Nation through preventive measures and restoration and recovery actions. DOE maintains a cadre of trained emergency responders who are able to rapidly deploy during national emergency declarations to areas where the energy infrastructure has been severely damaged. This established team of responders applies technical and emergency management expertise in an effort to overcome the challenges inherent in complex U.S. energy systems. DOE has also assigned dedicated personnel to each of the ten regional offices of the Federal Emergency Management Agency (FEMA) to organize and coordinate these activities on behalf of the Department." See the DOE website for additional information. http://energy.gov/oe/services/energy-assurance/response-and-restoration/esf-12-events.

[4] "Major Power Outage Hits New York, Other Large Cities," CNN.com, August 14, 2003, http://www.cnn.com/2003/US/08/14/power.outage/.

[5] "Biggest Blackout in U.S. History," CBS News, http://www.cbsnews.com/2100-201_162-568422.html.

[6] Elisabeth Bumiller, "The Blackout of 2003: The President: Bush Doesn't Let Blackout Upset Lunch with Troops," The New York Times, August 15, 2003, www.nytimes.com.

[7] As the United States develops new sources of energy, especially natural gas, that balance may shift over the next twenty years, making the United States a net exporter of energy.

[8] These figures are drawn from the Annual Energy Review, U.S. Energy Information Administration, September 2012, http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0101 and the International Energy Outlook 2011, U.S. International Energy Administration, ftp://ftp.eia.doe.gov/pub/pdf/international/0484(2003).pdf. The case cites figures from the 2003 version of the reports. More recent figures are available from the U.S. International Energy Administration.

[9] Department of Homeland Security Website, http://www.dhs.gov/energy-sector.

[10] Electric Power Industry Overview 2007, U.S. Energy Information Administration, 2007, http://www.eia.gov/cneaf/electricity/page/prim2/toc.2html#netw.

[11] Electric Power Industry Overview 2007, U.S. Energy Information Administration, 2007, http://www.eia.gov/cneaf/electricity/page/prim2/toc.2html#netw.

[12] http://www.dhs.gov/energy-sector

[13] Robert O'Harrow, Jr., "Cyber search engine Shodan exposes industrial control systems to new risks," *The New York Times*, June 3, 2012, http://www.washingtonpost.com/investigations/cyber-search-engine-exposes-vulnerabilities/2012/06/03/gJQAIK9KCV_story.html

[14] Gregory C. Wilhusen, "Cybersecurity, Challenges in Securing the electricity Grid. Statement of Gregory C. Wilhusen before the Committee on Energy and Natural Resources, U.S. Senate," Government Accountability Office, July 17, 2012, http://www.gao.gov/assets/600/592508.pdf.

[15] Timeline of Events leading to 2003 Blackout," August 14, 2008, http://usatoday30.usatoday.com/money/economy/2008-08-13-1092943286_x.htm This is a slightly edited version of what appeared in the article. This chronology has the benefit of hindsight after the report was finalized. Regarding "islanding," see Chapter 6 of the "Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations," U.S.-Canada Power System Outage Task Force, April 2004, https://reports.energy.gov/BlackoutFinal-Web.pdf.

[16] Thomas A. Fogarty and Fred Bayles, "Network Went Wobbly Hours Before Outage," *USA Today,* August 18, 2003.

[17] August 14th transcript of Midwest ISO control center from 1:00 to 5:00 pm Eastern Time, House Energy and Commerce Committee, September 2003, http://web.archive.org/web/20031002162105/http://energycommerce.house.gov/108/Hearings/09032003hearing1061/hearing.htm.

[18] August 14th transcript of Midwest ISO control center from 1:00 to 5:00 pm Eastern Time, House

Energy and Commerce Committee, September 2003, http://web.archive.org/web/20031002162105/http://energycommerce.house.gov/108/Hearings/09032003hearing1061/hearing.htm.

[19] Mark Clyton, "Progress on Preventing Blackouts," *Christian Science Monitor*, June 18, 2007.

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[21] New York Blackout, Blackout History Project, George Mason University, http://blackout.gmu.edu/events/tl1977.html.

[22] NERC Company History, NERC Website, http://www.nerc.com/page.php?cid=1%7C7%7C11

[23] NERC Company History, NERC Website, http://www.nerc.com/page.php?cid=1%7C7%7C11

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[35] For more cases that employ these and other techniques, please see Sarah Miller Beebe and Randolph H. Pherson, *Cases in Intelligence Analysis: Structured Analytic Techniques in Action,* Washington, DC: CQ Press, 2012.

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